

WHAT IS CLAIMED IS:

1. A positioning apparatus for determining a present position of a mobile station by using radio waves coming from a plurality of base stations arranged within a communication area, the positioning apparatus being arranged in said mobile station, the positioning apparatus comprising:

receiving means for receiving the radio waves coming from said plurality of base stations to generate reception signals corresponding to the respective radio waves;

direct wave candidate extracting means for extracting a plurality of direct wave candidates of the radio waves coming from said respective base stations, out of said reception signals generated by said receiving means;

deriving means for deriving reception signals equivalent to direct waves from said plurality of direct wave candidates extracted by said direct wave candidate extracting means; and

positioning operation means for determining the present position of said mobile station from said reception signals derived by said deriving means.

2. A positioning apparatus for determining a present position of a mobile station by using radio waves coming from said mobile station to a plurality of base stations arranged within a communication area, the positioning apparatus being arranged on the base-station side, the positioning apparatus comprising:

receiving means for receiving the radio waves coming from

said mobile station to generate reception signals corresponding to the respective radio waves, said receiving means being arranged in each of said plurality of base stations;

direct wave candidate extracting means for extracting a  
5 plurality of direct wave candidates of the radio waves coming to said respective base stations, out of said reception signals generated by said receiving means;

deriving means for deriving reception signals equivalent to direct waves from said plurality of direct wave candidates  
10 extracted by said direct wave candidate extracting means; and

positioning operation means for determining the present position of said mobile station from said reception signals derived by said deriving means.

15 3. The positioning apparatus according to claim 1 or 2, wherein said direct wave candidate extracting means extracts said direct wave candidates out of reception signals generated from radio waves coming to said receiving means within predetermined time since the point of start of positioning.

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4. The positioning apparatus according to claim 3, wherein said direct wave candidate extracting means extracts as said direct wave candidates a plurality of signals of greater reception intensities out of said reception signals generated from  
25 the radio waves coming to said receiving means within said predetermined time.

5. The positioning apparatus according to claim 3, wherein said predetermined time is set in accordance with sizes of communication areas of said respective base stations.

5 6. The positioning apparatus according to claim 3, wherein reception signals reaching predetermined reception intensities occur within said predetermined time.

7. The positioning apparatus according to claim 1, wherein:

said direct wave candidate extracting means extracts a plurality of direct wave candidates with respect to each of the radio waves coming from three base stations to said mobile station;

said deriving means performs a first direct wave deriving  
15 process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station and positioning errors in said approximate positions for said respective combinations and deriving said direct wave candidate corresponding to a positioning error of  
20 minimum value among said positioning errors determined for said respective combinations as said reception signal corresponding to the direct wave coming from a third base station out of said three base stations to said mobile station, said combinations being obtained by fixing two direct wave candidates selected in  
25 ones from among direct wave candidates corresponding to said first and second base stations while using direct wave candidates corresponding to said third base station as variables,

a second direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a second time and positioning errors in said approximate positions for a second time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the second time as said reception signal corresponding to the direct wave coming from said second base station to said mobile station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming from said third base station in said first direct wave deriving process and a direct wave candidate selected from among direct wave candidates corresponding to said first base station while using direct wave candidates corresponding to said second base station as variables, and

a third direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a third time and positioning errors in said approximate positions for a third time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the third time as said reception signal corresponding to the direct wave coming from said first base station to said mobile station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming from said

third base station in said first direct wave deriving process and said direct wave candidate derived as said reception signal resulting from the direct wave coming from said second base station in said second direct wave deriving process while using direct wave candidates corresponding to said first base station as variables; and

10 said positioning operation means determines the present position of said mobile station from three reception signals corresponding to the three direct waves from said first, second, and third base stations, said reception signals being obtained in said first, second, and third direct wave deriving processes.

8. The positioning apparatus according to claim 1, wherein:

15 said direct wave candidate extracting means extracts a plurality of direct wave candidates with respect to each of the radio waves coming from a plurality of base stations to said mobile station;

20 said deriving means obtains a plurality of combinations of direct wave candidates by combining direct wave candidates selected in ones from among those of said respective base stations extracted by said direct wave candidate extracting means, determines approximate positions of said mobile station and positioning errors in said approximate positions from said 25 plurality of combinations, respectively, and derives said direct wave candidates contained in a combination corresponding to said positioning error of minimum value as said reception signals

corresponding to the direct waves respectively coming from said plurality of base stations to said mobile station; and

said positioning operation means determines the present position of said mobile station from said reception signals corresponding to the direct waves respectively coming from said plurality of base stations, derived by said deriving means.

9. The positioning apparatus according to claim 2, wherein:

said direct wave candidate extracting means extracts a plurality of direct wave candidates with respect to each of the radio waves coming from said mobile station to three base stations;

said deriving means performs a first direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station and positioning errors in said approximate positions for said respective combinations and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for said respective combinations as said reception signal corresponding to the direct wave coming from said mobile station to a third base station out of said three base stations, said combinations being obtained by fixing two direct wave candidates selected in ones from among direct wave candidates corresponding to said first and second base stations while using direct wave candidates corresponding to said third base station as variables,

a second direct wave deriving process of performing

positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a second time and positioning errors in said approximate positions for a second time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the second time as said reception signal corresponding to the direct wave coming from said mobile station to said second base station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming to said third base station in said first direct wave deriving process and a direct wave candidate selected from among direct wave candidates corresponding to said first base station while using direct wave candidates corresponding to said second base station as variables, and

a third direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a third time and positioning errors in said approximate positions for a third time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the third time as said reception signal corresponding to the direct wave coming from said mobile station to said first base station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming to said third base station in said first direct wave deriving process and

said direct wave candidate derived as said reception signal resulting from the direct wave coming to said second base station in said second direct wave deriving process while using direct wave candidates corresponding to said first base station as variables; and

said positioning operation means determines the present position of said mobile station from reception signals corresponding to the direct waves from said mobile station to said first, second, and third base stations, said reception signals being obtained in said first, second, and third direct wave deriving processes.

10. The positioning apparatus according to claim 2, wherein:

said direct wave candidate extracting means extracts a plurality of direct wave candidates with respect to each of the radio waves coming from said mobile station to a plurality of base stations;

said deriving means obtains a plurality of combinations of direct wave candidates by combining direct wave candidates selected in ones from among those of said respective base stations extracted by said direct wave candidate extracting means, determines approximate positions of said mobile station and positioning errors in said approximate positions from said plurality of combinations, respectively, and derives said direct wave candidates contained in a combination corresponding to said positioning error of minimum value as said reception signals



corresponding to the direct waves respectively coming from said mobile station to said plurality of base stations; and

said positioning operation means determines the present position of said mobile station from said reception signals  
5 corresponding to the direct waves respectively coming to said plurality of base stations, derived by said deriving means.

11. A positioning apparatus comprising first positioning means including said receiving means, said direct wave candidate  
10 extracting means, said deriving means, and said positioning operation means set forth in claim 1, further comprising:

second positioning means for determining the present position of said mobile station by using the GPS; and

control means for switching to the positioning by said second  
15 positioning means in cases where the present position of said mobile station determined by said first positioning means exceeds a predetermined positioning error.

12. A positioning apparatus comprising first positioning  
20 means including said receiving means, said direct wave candidate extracting means, said deriving means, and said positioning operation means set forth in claim 1, further comprising:

second positioning means for determining the present position of said mobile station by using the GPS;

25 power supply means for supplying driving power to said first and second positioning means; and

power supply control means for detecting a remaining amount

of charge of said power supply means and switching the supply of said driving power from said power supply means between said first positioning means and said second positioning means, depending on the remaining amount of charge detected.

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13. A positioning method for determining a present position of a mobile station by using radio waves coming from a plurality of base stations arranged within a communication area to said mobile station, the positioning method comprising:

10 a first step of receiving the radio waves coming from said plurality of base stations to generate reception signals corresponding to the respective radio waves;

a second step of extracting a plurality of direct wave candidates of the radio waves coming from said respective base stations, out of said reception signals generated;

15 a third step of deriving reception signals equivalent to direct waves from said plurality of direct wave candidates extracted; and

a fourth step of determining the present position of said mobile station from said reception signals derived.

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14. A positioning method for determining a present position of a mobile station by using radio waves coming from said mobile station to a plurality of base stations arranged within a communication area, the positioning method comprising:

25

a first step of receiving the radio waves coming from said mobile station to said plurality of base stations by said plurality

of base stations and generating reception signals corresponding to the respective radio waves;

a second step of extracting a plurality of direct wave candidates of the radio waves coming to said respective base stations, out of said reception signals generated;

a third step of deriving reception signals equivalent to direct waves from said plurality of direct wave candidates extracted; and

a fourth step of determining the present position of said mobile station from said reception signals derived.

15. The positioning method according to claim 13 or 14, wherein said direct wave candidates are extracted from reception signals generated from radio waves received within predetermined time since the point of start of positioning in the first step.

16. The positioning method according to claim 13, wherein a plurality of signals of greater reception intensities out of said reception signals generated from radio waves received within predetermined time in the first step are extracted as said direct wave candidates.

17. The positioning method according to claim 13, wherein said predetermined time is set in accordance with the sizes of communication areas of said respective base stations.

18. The positioning method according to claim 13, wherein

reception signals reaching predetermined reception intensities occur within said predetermined time.

19. The positioning method according to claim 13,  
5 wherein:

in the second step, a plurality of direct wave candidates are extracted with respect to each of the radio waves coming from three base stations to said mobile station;

the third step includes a first direct wave deriving process  
10 of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station and positioning errors in said approximate positions for said respective combinations and deriving said direct wave candidate corresponding to a positioning error of minimum value  
15 among said positioning errors determined for said respective combinations as said reception signal corresponding to the direct wave coming from a third base station out of said three base stations to said mobile station, said combinations being obtained by fixing two direct wave candidates selected in ones from among  
20 direct wave candidates corresponding to said first and second base stations while using direct wave candidates corresponding to said third base station as variables,

a second direct wave deriving process of performing positioning operations on combinations of direct wave candidates  
25 to determine approximate positions of said mobile station for a second time and positioning errors in said approximate positions for a second time and deriving said direct wave candidate

corresponding to a positioning error of minimum value among said positioning errors determined for the second time as said reception signal corresponding to the direct wave coming from said second base station to said mobile station, said combinations  
5 being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming from said third base station in said first direct wave deriving process and a direct wave candidate selected from among direct wave candidates corresponding to said first base station while using  
10 direct wave candidates corresponding to said second base station as variables, and

a third direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a  
15 third time and positioning errors in said approximate positions for a third time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the third time as said reception signal corresponding to the direct wave coming from said first  
20 base station to said mobile station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming from said third base station in said first direct wave deriving process and said direct wave candidate derived as said reception signal  
25 resulting from the direct wave coming from said second base station in said second direct wave deriving process while using direct wave candidates corresponding to said first base station as

variables; and

in the fourth step, the present position of said mobile station is determined from said reception signals corresponding to the direct waves from said first, second, and third base stations, said reception signals being obtained in said first, second, and third direct wave deriving processes.

20. The positioning method according to claim 13, wherein:

10 in the second step, a plurality of direct wave candidates are extracted with respect to each of the radio waves coming from a plurality of base stations to said mobile station;

in the third step, a plurality of combinations of direct wave candidates are obtained by combining direct wave candidates selected in ones from among those of said respective base stations extracted in the second step, approximate positions of said mobile station and positioning errors in said approximate positions are determined from said plurality of combinations, respectively, and said direct wave candidates contained in a combination corresponding to said positioning error of minimum value are derived as said reception signals corresponding to the direct waves respectively coming from said plurality of base stations to said mobile station; and

in the fourth step, the present position of said mobile station is determined from said reception signals corresponding to the direct waves respectively coming from said plurality of base stations to said mobile station, derived in the third step.

21. The positioning method according to claim 14,  
wherein:

in the second step, a plurality of direct wave candidates  
5 are extracted with respect to each of the radio waves coming from  
said mobile station to three base stations;

the third step includes a first direct wave deriving process  
of performing positioning operations on combinations of direct  
wave candidates to determine approximate positions of said mobile  
10 station and positioning errors in said approximate positions for  
said respective combinations and deriving said direct wave  
candidate corresponding to a positioning error of minimum value  
among said positioning errors determined for said respective  
combinations as said reception signal corresponding to the direct  
15 wave coming from said mobile station to a third base station out  
of said three base stations, said combinations being obtained by  
fixing two direct wave candidates selected in ones from among  
direct wave candidates corresponding to said first and second base  
stations while using direct wave candidates corresponding to said  
20 third base station as variables,

a second direct wave deriving process of performing  
positioning operations on combinations of direct wave candidates  
to determine approximate positions of said mobile station for a  
second time and positioning errors in said approximate positions  
25 for a second time and deriving said direct wave candidate  
corresponding to a positioning error of minimum value among said  
positioning errors determined for the second time as said

reception signal corresponding to the direct wave coming to said second base station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming to said third base station in said first direct wave deriving process and a direct wave candidate selected from among direct wave candidates corresponding to said first base station while using direct wave candidates corresponding to said second base station as variables, and

10 a third direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a third time and positioning errors in said approximate positions for a third time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the third time as said reception signal corresponding to the direct wave coming to said first base station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming to said third base station in said first direct wave deriving process and said direct wave candidate derived as said reception signal resulting from the direct wave coming to said second base station in said second direct wave deriving process while using direct wave candidates corresponding to said first base station as variables; and

in the fourth step, the present position of said mobile station is determined from reception signals corresponding to the



direct waves from said mobile station to said first, second, and third base stations, said reception signals being obtained in said first, second, and third direct wave deriving processes.

5           22. The positioning method according to claim 14, wherein:

in the second step, a plurality of direct wave candidates are extracted with respect to each of the radio waves coming from said mobile station to a plurality of base stations;

10           in the third step, a plurality of combinations of direct wave candidates are obtained by combining direct wave candidates selected in ones from among those of said respective base stations extracted in the second step, approximate positions of said mobile station and positioning errors in said approximate positions are  
15 determined from said plurality of combinations, respectively, and said direct wave candidates contained in a combination corresponding to said positioning error of minimum value are derived as said reception signals corresponding to the direct waves respectively coming to said plurality of base stations; and

20           in the fourth step, the present position of said mobile station is determined from said reception signals corresponding to the direct waves respectively coming to said plurality of base stations, derived in the third step.

25           23. A positioning system for determining a present position of a mobile station lying within a communication area, a plurality of base stations being arranged within said

communication area,

said mobile station comprising:

receiving means for receiving radio waves coming from said plurality of base stations to generate reception signals  
5 corresponding to the respective radio waves;

direct wave candidate extracting means for extracting a plurality of direct wave candidates of the radio waves coming from said respective base stations, out of said reception signals generated by said receiving means;

10 deriving means for deriving reception signals equivalent to direct waves from said plurality of direct wave candidates extracted by said direct wave candidate extracting means; and

positioning operation means for determining the present position of said mobile station from said reception signals  
15 derived by said deriving means, wherein

the present position of said mobile station is determined on the mobile-station side by using the radio waves coming from a plurality of base stations arranged within said communication area to said mobile station.

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24. A positioning system for determining a present position of a mobile station lying in a communication area, a plurality of base stations being arranged within said communication area, the positioning system comprising:

25 receiving means for receiving radio waves coming from said mobile station to generate reception signals corresponding to the respective radio waves, said receiving means being arranged in

each of said plurality of base stations;

direct wave candidate extracting means for extracting a plurality of direct wave candidates of the radio waves coming to said respective base stations, out of said reception signals  
5 generated by said receiving means;

deriving means for deriving reception signals equivalent to direct waves from said plurality of direct wave candidates extracted by said direct wave candidate extracting means; and

positioning operation means for determining the present  
10 position of said mobile station from said reception signals derived by said deriving means, wherein

the present position of said mobile station is determined on the mobile-station side by using radio waves coming from said mobile station to a plurality of base stations arranged within  
15 said communication area.

25. The positioning system according to claim 23 or 24, wherein said direct wave candidate extracting means extracts said direct wave candidates out of reception signals generated from  
20 radio waves coming to said receiving means within predetermined time since the point of start of positioning.

26. The positioning system according to claim 25, wherein said direct wave candidate extracting means extracts as said  
25 direct wave candidates a plurality of signals of greater reception intensities out of said reception signals generated from the radio waves coming to said receiving means within said predetermined

time.

27. The positioning system according to claim 25, wherein said predetermined time is set in accordance with sizes of communication areas of said respective base stations.

28. The positioning system according to claim 25, wherein reception signals reaching predetermined reception intensities occur within said predetermined time.

29. The positioning system according to claim 23, wherein:

said direct wave candidate extracting means extracts a plurality of direct wave candidates with respect to each of the radio waves coming from three base stations to said mobile station;

said deriving means performs a first direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station and positioning errors in said approximate positions for said respective combinations and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for said respective combinations as said reception signal corresponding to the direct wave coming from a third base station out of said three base stations to said mobile station, said combinations being obtained by fixing two direct wave candidates selected in ones from among direct wave candidates corresponding to said first

and second base stations while using direct wave candidates corresponding to said third base station as variables,

5 a second direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a second time and positioning errors in said approximate positions for a second time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the second time as said  
10 reception signal corresponding to the direct wave coming from said second base station to said mobile station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming from said third base station in said first direct wave deriving process  
15 and a direct wave candidate selected from among direct wave candidates corresponding to said first base station while using direct wave candidates corresponding to said second base station as variables, and

20 a third direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a third time and positioning errors in said approximate positions for a third time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said  
25 positioning errors determined for the third time as said reception signal corresponding to the direct wave coming from said first base station to said mobile station, said combinations being

obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming from said third base station in said first direct wave deriving process and said direct wave candidate derived as said reception signal  
5 resulting from the direct wave coming from said second base station in said second direct wave deriving process while using direct wave candidates corresponding to said first base station as variables; and

10 said positioning operation means determines the present position of said mobile station from reception signals corresponding to the direct waves from said first, second, and third base stations, said reception signals being obtained in said first, second, and third direct wave deriving processes.

15 30. The positioning system according to claim 23, wherein:

said direct wave candidate extracting means extracts a plurality of direct wave candidates with respect to each of the radio waves coming from a plurality of base stations to said mobile  
20 station;

said deriving means obtains a plurality of combinations of direct wave candidates by combining direct wave candidates selected in ones from among those of said respective base stations extracted by said direct wave candidate extracting means,  
25 determines approximate positions of said mobile station and positioning errors in said approximate positions from said plurality of combinations, respectively, and derives said direct

wave candidates contained in a combination corresponding to said positioning error of minimum value as said reception signals corresponding to the direct waves respectively coming from said plurality of base stations to said mobile station; and

5        said positioning operation means determines the present position of said mobile station from said reception signals corresponding to the direct waves respectively coming from said plurality of base stations to said mobile station, derived by said deriving means.

10

31.    The positioning system according to claim 24, wherein:

15        said direct wave candidate extracting means extracts a plurality of direct wave candidates with respect to each of the radio waves coming from said mobile station to three base stations;

20        said deriving means performs a first direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station and positioning errors in said approximate positions for said respective combinations and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for said respective combinations as said reception signal corresponding to the direct wave coming from said mobile station to a third base station out of said three base stations, said combinations being  
25        obtained by fixing two direct wave candidates selected in ones from among direct wave candidates corresponding to said first and

second base stations while using direct wave candidates corresponding to said third base station as variables,

a second direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a second time and positioning errors in said approximate positions for a second time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the second time as said reception signal corresponding to the direct wave coming to said second base station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming to said third base station in said first direct wave deriving process and a direct wave candidate selected from among direct wave candidates corresponding to said first base station while using direct wave candidates corresponding to said second base station as variables, and

a third direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a third time and positioning errors in said approximate positions for a third time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the third time as said reception signal corresponding to the direct wave coming to said first base station, said combinations being obtained by fixing said direct



wave candidate derived as said reception signal resulting from the direct wave coming to said third base station in said first direct wave deriving process and said direct wave candidate derived as said reception signal resulting from the direct wave coming to said second base station in said second direct wave deriving process while using direct wave candidates corresponding to said first base station as variables; and

said positioning operation means determines the present position of said mobile station from reception signals corresponding to the direct waves from said mobile station to said first, second, and third base stations, said reception signals being obtained in said first, second, and third direct wave deriving processes.

32. The positioning system according to claim 24, wherein:

said direct wave candidate extracting means extract a plurality of direct wave candidates with respect to each of the radio waves coming from said mobile station to a plurality of base stations;

said deriving means obtains a plurality of combinations of direct wave candidates by combining direct wave candidates selected in ones from among those of said respective base stations extracted by said direct wave candidate extracting means, determines approximate positions of said mobile station and positioning errors in said approximate positions from said plurality of combinations, respectively, and derives said direct

wave candidates contained in a combination corresponding to said positioning error of minimum value as said reception signals corresponding to the direct waves respectively coming to said plurality of base stations; and

5        said positioning operation means determines the present position of said mobile station from said reception signals corresponding to the direct waves respectively coming to said plurality of base stations, derived by said deriving means.

10        33.    A positioning apparatus for determining a present position of a mobile station by using radio waves coming from a plurality of base stations arranged within a communication area, the positioning apparatus being arranged in said mobile station, the positioning apparatus comprising:

15        a receiving unit which receives the radio waves coming from said plurality of base stations to generate reception signals corresponding to the respective radio waves;

20        a range measuring unit which extracts a plurality of direct wave candidates of the radio waves coming from said respective base stations, out of said reception signals generated by said receiving unit;

      a direct wave detecting unit which derives reception signals equivalent to direct waves from said plurality of direct wave candidates extracted by said range measuring unit; and

25        a position computing unit which determines the present position of said mobile station from said reception signals derived by said direct wave detecting unit.

34. A positioning apparatus for determining a present position of a mobile station by using radio waves coming from said mobile station to a plurality of base stations arranged within  
5 a communication area, the positioning apparatus being arranged on the base-station side, the positioning apparatus comprising:

a receiving unit which receives the radio waves coming from said mobile station to generate reception signals corresponding to the respective radio waves, said receiving unit being arranged  
10 in each of said plurality of base stations;

a range measuring unit which extracts a plurality of direct wave candidates of the radio waves coming to said respective base stations, out of said reception signals generated by said receiving unit;

15 a direct wave detecting unit which derives reception signals equivalent to direct waves from said plurality of direct wave candidates extracted by said range measuring unit; and

a position computing unit which determines the present position of said mobile station from said reception signals  
20 derived by said direct wave detecting unit.

35. The positioning apparatus according to claim 33 or 34, wherein said range measuring unit extracts said direct wave candidates out of reception signals generated from radio waves  
25 coming to said receiving unit within predetermined time since the point of start of positioning.

36. The positioning apparatus according to claim 35,  
wherein said range measuring unit extracts as said direct wave  
candidates a plurality of signals of greater reception intensities  
out of said reception signals generated from the radio waves coming  
5 to said receiving unit within said predetermined time.

37. The positioning apparatus according to claim 35,  
wherein said predetermined time is set in accordance with  
respective sizes of communication areas of said respective base  
10 stations.

38. The positioning apparatus according to claim 35,  
wherein reception signals reaching predetermined reception  
intensities occur within said predetermined time.

39. The positioning apparatus according to claim 33,  
wherein:

said range measuring unit extracts a plurality of direct  
wave candidates with respect to each of the radio waves coming  
20 from three base stations to said mobile station;

said direct wave detecting unit performs a first direct wave  
deriving process of performing positioning operations on  
combinations of direct wave candidates to determine approximate  
positions of said mobile station and positioning errors in said  
25 approximate positions for said respective combinations and  
deriving said direct wave candidate corresponding to a positioning  
error of minimum value among said positioning errors determined

for said respective combinations as said reception signal corresponding to the direct wave coming from a third base station out of said three base stations to said mobile station, said combinations being obtained by fixing two direct wave candidates selected in ones from among direct wave candidates corresponding to said first and second base stations while using direct wave candidates corresponding to said third base station as variables,

5 a second direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a second time and positioning errors in said approximate positions for a second time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the second time as said reception signal corresponding to the direct wave coming from said second base station to said mobile station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming from said third base station in said first direct wave deriving process and a direct wave candidate selected from among direct wave candidates corresponding to said first base station while using direct wave candidates corresponding to said second base station as variables, and

10 a third direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a third time and positioning errors in said approximate positions

for a third time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the third time as said reception signal corresponding to the direct wave coming from said first base station to said mobile station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming from said third base station in said first direct wave deriving process and said direct wave candidate derived as said reception signal resulting from the direct wave coming from said second base station in said second direct wave deriving process while using direct wave candidates corresponding to said first base station as variables; and

said position computing unit determines the present position of said mobile station from three reception signals corresponding to the three direct waves from said first, second, and third base stations, said reception signals being obtained in said first, second, and third direct wave deriving processes.

40. The positioning apparatus according to claim 33, wherein:

said range measuring unit extracts a plurality of direct wave candidates with respect to each of the radio waves coming from a plurality of base stations to said mobile station;

said direct wave detecting unit obtains a plurality of combinations of direct wave candidates by combining direct wave candidates selected in ones from among those of said respective

base stations extracted by said range measuring unit, determines approximate positions of said mobile station and positioning errors in said approximate positions from said plurality of combinations, respectively, and derives said direct wave candidates contained in a combination corresponding to said positioning error of minimum value as said reception signals corresponding to the direct waves respectively coming from said plurality of base stations to said mobile station; and

said position computing unit determines the present position of said mobile station from said reception signals corresponding to the direct waves respectively coming from said plurality of base stations, derived by said direct wave detecting unit.

41. The positioning apparatus according to claim 34, wherein:

said range measuring unit extracts a plurality of direct wave candidates with respect to each of the radio waves coming from said mobile station to three base stations;

said direct wave detecting unit performs a first direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station and positioning errors in said approximate positions for said respective combinations and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for said respective combinations as said reception signal

corresponding to the direct wave coming from said mobile station to a third base station out of said three base stations, said combinations being obtained by fixing two direct wave candidates selected in ones from among direct wave candidates corresponding to said first and second base stations while using direct wave candidates corresponding to said third base station as variables,

5 a second direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a second time and positioning errors in said approximate positions for a second time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the second time as said reception signal corresponding to the direct wave coming from said mobile station to said second base station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming to said third base station in said first direct wave deriving process and a direct wave candidate selected from among direct wave candidates corresponding to said first base station while using direct wave candidates corresponding to said second base station as variables, and

10 a third direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a third time and positioning errors in said approximate positions for a third time and deriving said direct wave candidate



corresponding to a positioning error of minimum value among said positioning errors determined for the third time as said reception signal corresponding to the direct wave coming from said mobile station to said first base station, said combinations being  
5 obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming to said third base station in said first direct wave deriving process and said direct wave candidate derived as said reception signal resulting from the direct wave coming to said second base station  
10 in said second direct wave deriving process while using direct wave candidates corresponding to said first base station as variables; and

said position computing unit determines the present position of said mobile station from reception signals  
15 corresponding to the direct waves from said mobile station to said first, second, and third base stations, said reception signals being obtained in said first, second, and third direct wave deriving processes.

20 42. The positioning apparatus according to claim 34, wherein:

said range measuring unit extracts a plurality of direct wave candidates with respect to each of the radio waves coming from said mobile station to a plurality of base stations;

25 said direct wave detecting unit obtains a plurality of combinations of direct wave candidates by combining direct wave candidates selected in ones from among those of said respective

base stations extracted by said range measuring unit, determines approximate positions of said mobile station and positioning errors in said approximate positions from said plurality of combinations, respectively, and derives said direct wave candidates contained in a combination corresponding to said positioning error of minimum value as said reception signals corresponding to the direct waves respectively coming from said mobile station to said plurality of base stations; and

said position computing unit determines the present position of said mobile station from said reception signals corresponding to the direct waves respectively coming to said plurality of base stations, derived by said direct wave detecting unit.

43. A positioning apparatus comprising a first positioning device including said receiving unit, said range measuring unit, said direct wave detecting unit, and said position computing unit set forth in claim 33, further comprising:

a second positioning device which determines the present position of said mobile station by using the GPS; and

a control unit which switches to the positioning by said second positioning device in cases where the present position of said mobile station determined by said first positioning device exceeds a predetermined positioning error.

44. A positioning apparatus comprising a first positioning device including said receiving unit, said range

measuring unit, said direct wave detecting unit, and said positioning computing unit set forth in claim 33, further comprising:

a second positioning device which determines the present position of said mobile station by using the GPS;

a power supply which supplies driving power to said first and second positioning device; and

a power supply control unit which detects a remaining amount of charge of said power supply and switches the supply of said driving power from said power supply between said first positioning device and said second positioning device, depending on the remaining amount of charge detected.

45. A positioning system for determining a present position of a mobile station lying within a communication area, a plurality of base stations being arranged within said communication area,

said mobile station comprising:

a receiving unit which receives radio waves coming from said plurality of base stations to generate reception signals corresponding to the respective radio waves;

a range measuring unit which extracts a plurality of direct wave candidates of the radio waves coming from said respective base stations, out of said reception signals generated by said receiving unit;

a direct wave detecting unit which derives reception signals equivalent to direct waves from said plurality of direct wave

candidates extracted by said range measuring unit; and

a position computing unit which determines the present position of said mobile station from said reception signals derived by said direct wave detecting unit, wherein

5        the present position of said mobile station is determined on the mobile-station side by using the radio waves coming from a plurality of base stations arranged within said communication area to said mobile station.

10        46. A positioning system for determining a present position of a mobile station lying in a communication area, a plurality of base stations being arranged within said communication area, the positioning system comprising:

15        a receiving unit which receives radio waves coming from said mobile station to generate reception signals corresponding to the respective radio waves, said receiving unit being arranged in each of said plurality of base stations;

20        a range measuring unit which extracts a plurality of direct wave candidates of the radio waves coming to said respective base stations, out of said reception signals generated by said receiving unit;

a direct wave detecting unit which derives reception signals equivalent to direct waves from said plurality of direct wave candidates extracted by said range measuring unit; and

25        a position computing unit which determines the present position of said mobile station from said reception signals derived by said direct wave detecting unit,

wherein the present position of said mobile station is determined on the base-station side by using radio waves coming from said mobile station to a plurality of base stations arranged within said communication area.

5

47. The positioning system according to claim 45 or 46, wherein said range measuring unit extracts said direct wave candidates out of reception signals generated from radio waves coming to said receiving unit within predetermined time since the point of start of positioning.

10

48. The positioning system according to claim 47, wherein said range measuring unit extracts as said direct wave candidates a plurality of signals of greater reception intensities out of said reception signals generated from the radio waves coming to said receiving unit within said predetermined time.

15

49. The positioning system according to claim 47, wherein said predetermined time is set in accordance with a size of communication area of said respective base stations.

20

50. The positioning system according to claim 47, wherein reception signals reaching predetermined reception intensities occur within said predetermined time.

25

51. The positioning system according to claim 45, wherein:

said range measuring unit extracts a plurality of direct wave candidates with respect to each of the radio waves coming from three base stations to said mobile station;

said direct wave detecting unit performs a first direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station and positioning errors in said approximate positions for said respective combinations and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for said respective combinations as said reception signal corresponding to the direct wave coming from a third base station out of said three base stations to said mobile station, said combinations being obtained by fixing two direct wave candidates selected in ones from among direct wave candidates corresponding to said first and second base stations while using direct wave candidates corresponding to said third base station as variables,

a second direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a second time and positioning errors in said approximate positions for a second time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the second time as said reception signal corresponding to the direct wave coming from said second base station to said mobile station, said combinations being obtained by fixing said direct wave candidate derived as

said reception signal resulting from the direct wave coming from said third base station in said first direct wave deriving process and a direct wave candidate selected from among direct wave candidates corresponding to said first base station while using  
5 direct wave candidates corresponding to said second base station as variables, and

a third direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a  
10 third time and positioning errors in said approximate positions for a third time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the third time as said reception  
15 signal corresponding to the direct wave coming from said first base station to said mobile station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming from said  
20 third base station in said first direct wave deriving process and said direct wave candidate derived as said reception signal resulting from the direct wave coming from said second base station in said second direct wave deriving process while using direct wave candidates corresponding to said first base station as variables; and

said position computing unit determines the present  
25 position of said mobile station from reception signals corresponding to the direct waves from said first, second, and third base stations, said reception signals being obtained in said

first, second, and third direct wave deriving processes.

52. The positioning system according to claim 45,  
wherein:

5       said range measuring unit extracts a plurality of direct  
wave candidates with respect to each of the radio waves coming  
from a plurality of base stations to said mobile station;

10       said direct wave detecting unit obtains a plurality of  
combinations of direct wave candidates by combining direct wave  
candidates selected in ones from among those of said respective  
base stations extracted by said range measuring unit, determines  
approximate positions of said mobile station and positioning  
errors in said approximate positions from said plurality of  
combinations, respectively, and derives said direct wave  
15 candidates contained in a combination corresponding to said  
positioning error of minimum value as said reception signals  
corresponding to the direct waves respectively coming from said  
plurality of base stations to said mobile station; and

20       said position computing unit determines the present  
position of said mobile station from said reception signals  
corresponding to the direct waves respectively coming from said  
plurality of base stations to said mobile station, derived by said  
direct wave detecting unit.

25       53. The positioning system according to claim 46,  
wherein:

      said range measuring unit extracts a plurality of direct



wave candidates with respect to each of the radio waves coming from said mobile station to three base stations;

said direct wave detecting unit performs a first direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station and positioning errors in said approximate positions for said respective combinations and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for said respective combinations as said reception signal corresponding to the direct wave coming from said mobile station to a third base station out of said three base stations, said combinations being obtained by fixing two direct wave candidates selected in ones from among direct wave candidates corresponding to said first and second base stations while using direct wave candidates corresponding to said third base station as variables;

a second direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a second time and positioning errors in said approximate positions for a second time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said positioning errors determined for the second time as said reception signal corresponding to the direct wave coming to said second base station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from the direct wave coming to said third base station

in said first direct wave deriving process and a direct wave candidate selected from among direct wave candidates corresponding to said first base station while using direct wave candidates corresponding to said second base station as variables;

5           a third direct wave deriving process of performing positioning operations on combinations of direct wave candidates to determine approximate positions of said mobile station for a third time and positioning errors in said approximate positions for a third time and deriving said direct wave candidate corresponding to a positioning error of minimum value among said  
10           positioning errors determined for the third time as said reception signal corresponding to the direct wave coming to said first base station, said combinations being obtained by fixing said direct wave candidate derived as said reception signal resulting from  
15           the direct wave coming to said third base station in said first direct wave deriving process and said direct wave candidate derived as said reception signal resulting from the direct wave coming to said second base station in said second direct wave deriving process while using direct wave candidates corresponding  
20           to said first base station as variables; and

          said position computing unit determines the present position of said mobile station from reception signals corresponding to the direct waves from said mobile station to said first, second, and third base stations, said reception signals  
25           being obtained in said first, second, and third direct wave deriving processes.

54. The positioning system according to claim 46,  
wherein:

said range measuring unit extracts a plurality of direct  
wave candidates with respect to each of the radio waves coming  
5 from said mobile station to a plurality of base stations;

said direct wave detecting unit obtains a plurality of  
combinations of direct wave candidates by combining direct wave  
candidates selected in ones from among those of said respective  
base stations extracted by said range measuring unit, determines  
10 approximate positions of said mobile station and positioning  
errors in said approximate positions from said plurality of  
combinations, respectively, and derives said direct wave  
candidates contained in a combination corresponding to said  
positioning error of minimum value as said reception signals  
15 corresponding to the direct waves respectively coming to said  
plurality of base stations; and

said position computing unit determines the present  
position of said mobile station from said reception signals  
corresponding to the direct waves respectively coming to said  
20 plurality of base stations, derived by said direct wave detecting  
unit.